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Department of the Navy
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STATIC FORCE COEFFICIENTS OF WEAPON "A" IN FULLY WETTED FLOW

R. W. Kermeen

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Pasadena, California

Report No. E-73.7

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ABSTRACT

The results of static force tests on a 2-in. diameter model of Weapon "A" in the High Speed Water Tunnel are presented. Drag coefficient was measured for Reynolds numbers from 1.3 to 8.0 x 10^6 at zero degrees attack angle. Lift, drag, and pitching moment were measured as a function of attack angle for Reynolds numbers of 3.8 and 5.1 x 10^6.

MODEL

The principal dimensions of Weapon "A" are shown in the sketch Fig. 1. The 2-in. diameter model was supported in the tunnel at 2.806 d from the nose. The moments are referred to the c.g. after firing 2.306 d from the nose. The prototype fins are canted at 7 degrees; however, the model was made with purely radial fins since it was restrained from rolling in these tests.

EXPERIMENTAL SETUP AND TEST PROCEDURE

The model was supported on the three-component static force balance[1] in the High Speed Water Tunnel[2] on a single, shielded strut. In order to evaluate and correct for the strut and shield interference effects, each run was repeated with a second image shield mounted from the opposite side of the test section. Assuming that the effects of the shields are additive, the difference between the nonimage and image runs gives the interference correction for a single shield. This difference was then subtracted from the nonimage run.

Two series of tests were made. Drag was measured at zero attack angle for a range of tunnel velocities from 10 to 60 fps giving Reynolds numbers, based on model length, from 1.3 to 8.0×10^6. In a second series of runs the lift, drag, and pitching moment were measured as functions of angle of attack at velocities of 30 and 40 fps.

Descriptions of the balance, data read-out system, and methods of data reduction are given in Refs. 1 and 3. The force data were reduced to dimensionless coefficients, as follows:

$$\text{Lift coefficient, } C_L = \frac{\text{Lift}}{\rho/2\ V^2\ A}$$

$$\text{Drag coefficient, } C_D = \frac{\text{Drag}}{\rho/2\ V^2\ A}$$

$$\text{Moment Coefficient, } C_M = \frac{\text{Pitching moment about c.g.}}{\rho/2\ V^2\ Ad}$$

$$\text{Reynolds number, } R_\ell = \frac{V\ell}{\nu}$$

where

ρ = density of water, slugs/ft^3

V = velocity of free stream, ft/sec

A = $\frac{\pi d^2}{4}$ = cross sectional area, ft^2

d = model diameter, ft

ν = kinematic viscosity of water at temperature of run, ft^2/sec

ℓ = model length, ft

The moments are referred to the c.g. point after firing, 2.306 d from the model nose. In addition to the shield interference corrections, the drag coefficient was corrected for horizontal buoyancy, the spurious drag due to the pressure gradient along the tunnel test section.

RESULTS AND DISCUSSION

Drag coefficient is shown as a function of Reynolds number at zero degrees attack angle in Fig. 2, and lift, drag, and pitching moment coefficients are shown as functions of angle of attack at velocities of 30 and 40 fps in Fig. 3. The Weapon "A" configuration was tested in the Hydrodynamics Laboratory in 1947[4]. The drag coefficient reported in Ref. 4 is 18 percent higher at a Reynolds number of 2.5×10^6 and 5 percent higher at a Reynolds number of 7.0×10^6. This difference in drag coefficients reflects the modification and improvements in the tunnel force balance system. Drag coefficients reported from tests in the High Speed Water Tunnel prior to 1952 may be subject to such errors. These errors arose from a drag-pitching moment interaction inherent in the force balance design. Between 1952 and 1954 internal pitching moment balances inside the models were used to measure the spurious pitching moment[5], and these measurements were used to correct the combined drag and moments measured on the external force balance. In 1954 the balance modifications described in Ref. 1 were made and the force-moment interactions eliminated. The lift and moment coefficients are in fair agreement between the present tests and those reported in Ref. 4.

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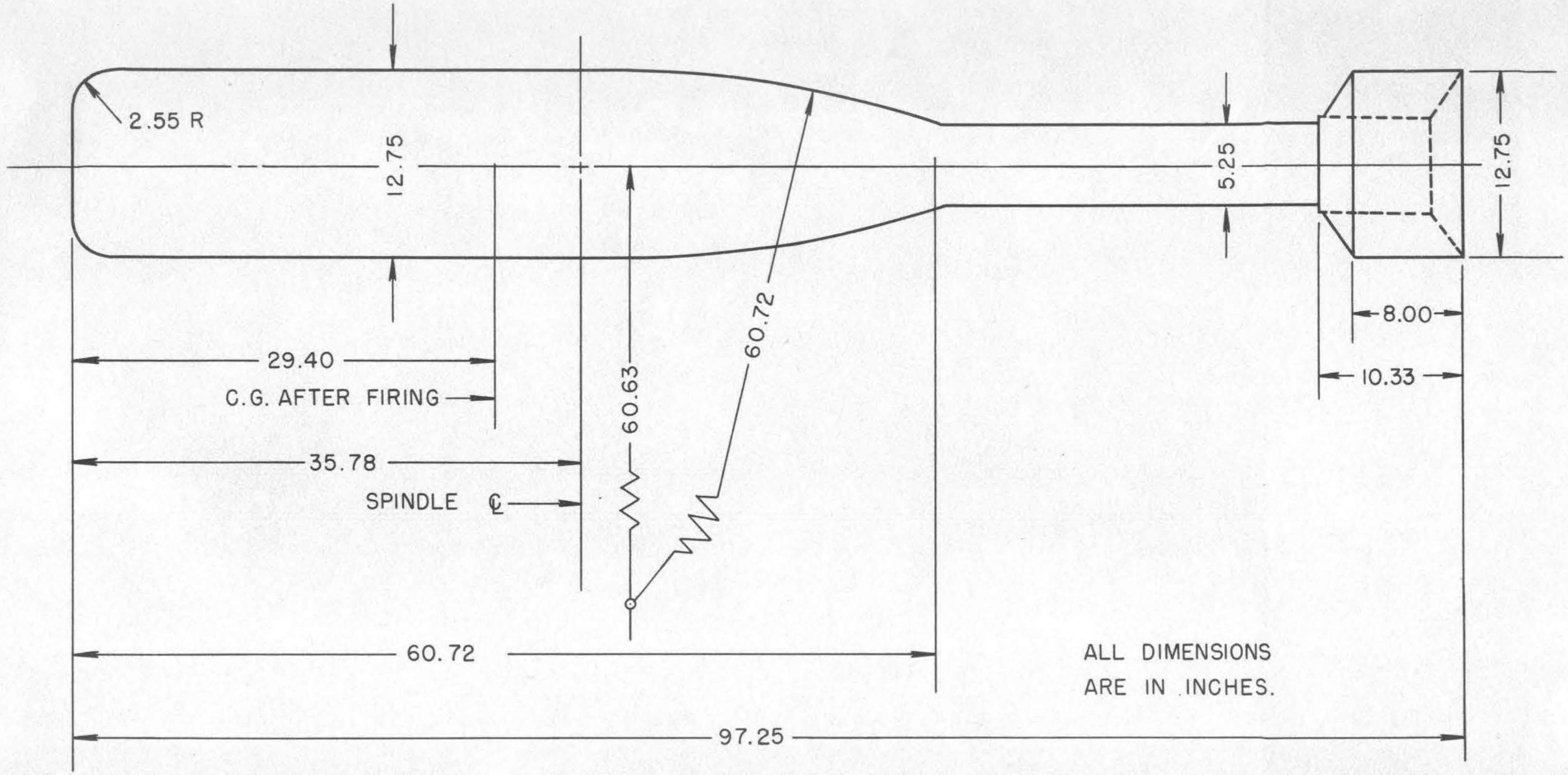

Fig. 1. Outline and principal dimensions of Weapon A.

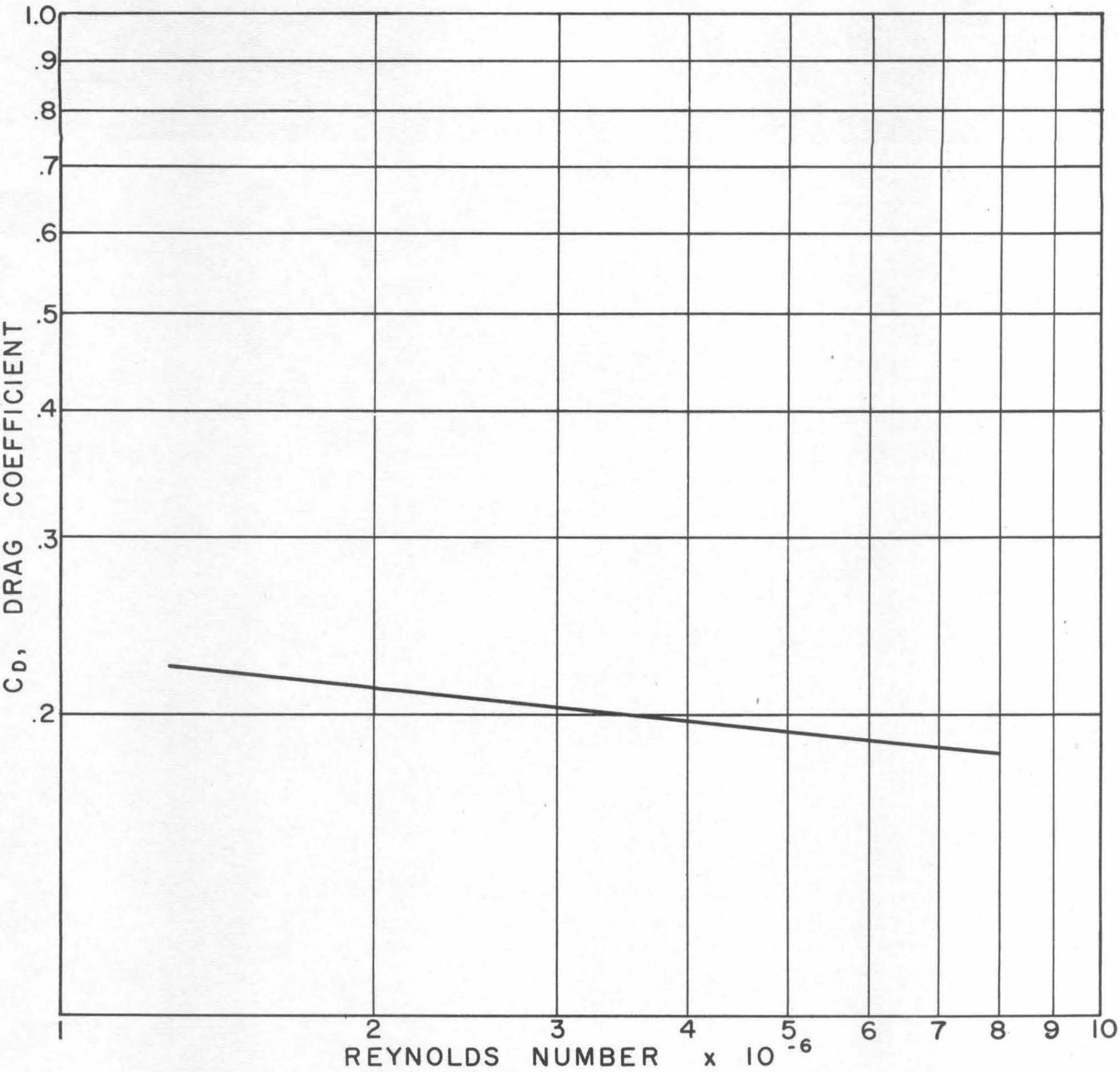

Fig. 2. Drag coefficient as a function of Reynolds number for 2-in. diameter model of Weapon A.

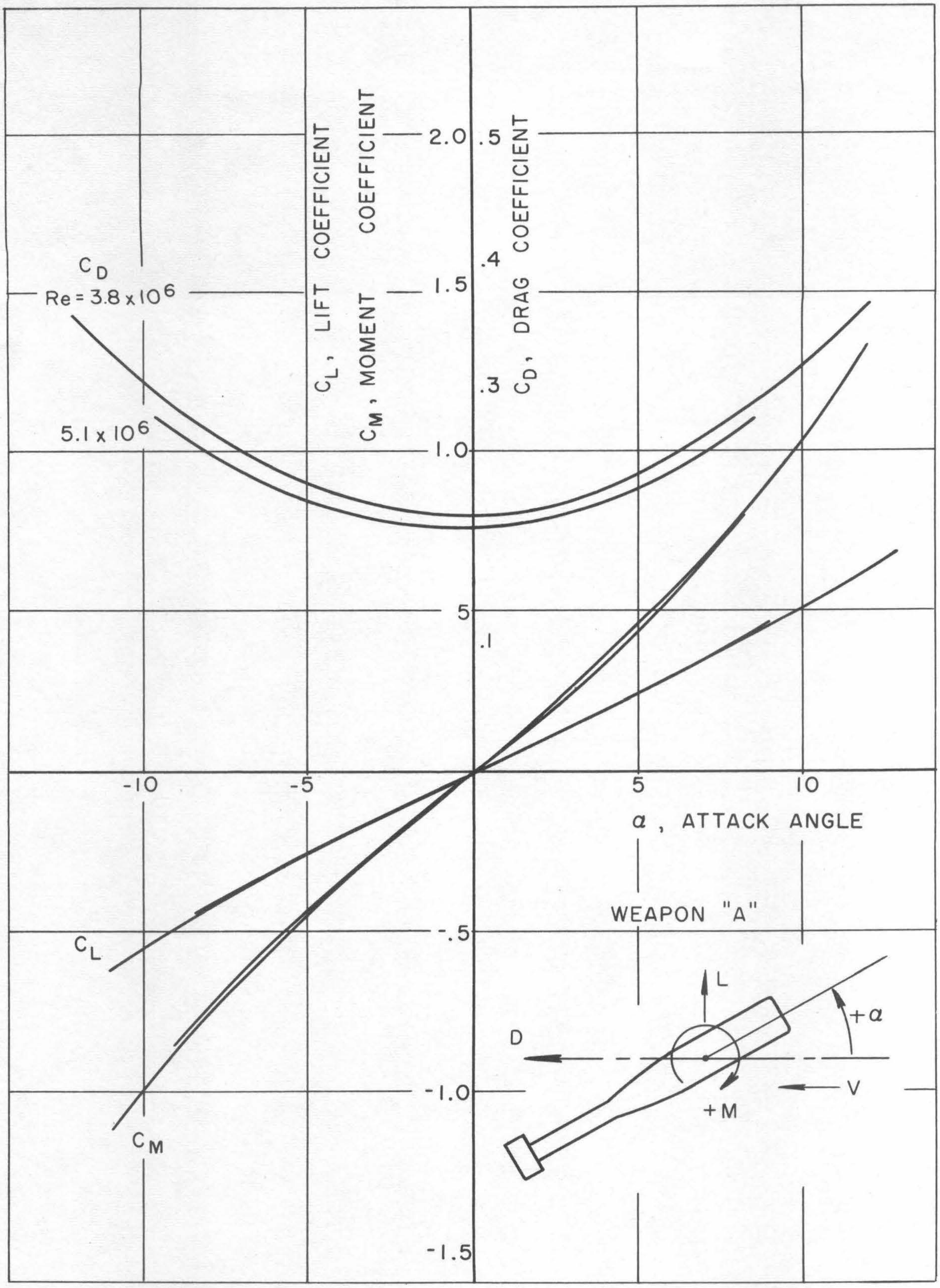

Fig. 3. Drag, lift and moment coefficients as functions of angle of attack for Weapon A.

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